THE TRUNK SEWER OF BUFFALO, N. Y.

Its Construction, Cost and Operation.

By

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The following account of the Trunk Sewer has been prepared for the people of Buffalo, with a view to a popular understanding of its purpose and of its performance.

G. E. W., Jr.

Sketch of the
MAIN PART OF
BUFFALO
WITH LOCATION OF THE
TRUNK SEWER.
(MANY STREETS OMITTED.)

Only principal streets are given to indicate the general location of the sewer. The Hamburg Canal is a *cul-de-sac* connected with the Erie Canal.

At the sewer outlet (Albany street) a second body of water is inclosed, outside of the Erie Canal, by a stone pier, forming the east bank of Niagara River. It is at the face of this pier that the sewer discharges.

THE TRUNK SEWER.

The Three Plans.

July 29, 1880, Messrs. Youngs, Adams and Lane reported a plan for a trunk sewer in Buffalo, from Hamburg street to Albany street, to be substantially eleven feet in diameter at Hamburg street and twelve feet in diameter from Genesee street to the outlet. Its course was laid along the north bank of the Hamburg Canal, thence to the Lower Terrace, and thence to Albany street on the line of the present sewer. The passage under the canal, at Albany street, was by a vertical shaft and tunnel.

December 24, 1881, Messrs. Smith, Chesbrough and Shedd made a report, recommending a sewer from Hydraulic street to Hamburg street nine feet eight inches in diameter, thence to Genesee street eleven feet seven inches in diameter, thence to Albany street eleven feet eleven inches in diameter. The location of the previous commission was accepted below Erie street; from Erie street to Hydraulic street it was proposed to lay the sewer in Seneca street. It was recommended that the outfall well and tunnel be modified "by rounding off as far as possible all square corners and avoiding all unnecessary enlargements of water-ways."

August 17, 1882, I made a report, recommending a sewer eight feet in diameter from Hamburg street to Albany street, having an outlet under the canal and harbor eight feet six inches in diameter and having its upper end connected with the Mill-race sewer at Hydraulic street by a sewer four feet in

diameter. I advised laying the sewer in Swan street instead of Seneca street and following the route accepted by the previous commission from the Terrace to Albany street.

This plan was followed in the construction of the existing sewer.

The Purpose of the Sewer.

The purpose of this sewer, as indicated in my report, was to provide a channel, covered throughout its whole length, carrying a constant stream of sufficient depth and velocity to receive, and to remove promptly, the dry-weather flow of all of the city sewers that could be connected with it—practically all north of the Hamburg Canal and Little Buffalo Creek, as far as the crest separating the main area of the city from the Bird Avenue sewer district. It was assumed that the depth of this stream would be at least two and one-fourth feet and that its velocity would be sufficient to carry to the outlet whatever it might receive from the city sewers—not less than two feet per second.

In addition to this, there would be ample capacity to receive and transport a very large proportion of the storm water flow of the city sewers—all of their early flow, containing the deposited filth washed out of them at the beginning of each storm.

Incidentally, and as a means for providing the constant stream by which sewage was to be transported, water was to be drawn from the Hamburg Canal, causing, of course, an equal indraft from the lake or river.

In my report, I spoke of this sewer as "needed to withhold the putrescible organic matter by which the canal water is now made foul. * * * There can be no more perfect means devised for securing the end in view than to establish a strong, active and constant current, in a channel specially provided for the purpose, sufficient to wash into Niagara River, below

the intake of the water works, those foul substances which, under present conditions, are deposited in the canals." * * *

"We have, in the inexhaustible supply of the canal, more than we need for such constant flushing as will keep the sewer always clean to its invert if it be of only ample proportions." * * * "At its upper end, the invert of the sewer will be 2.43 feet below the ordinary level of the water of the Hamburg Canal. Flushing water will be admitted from the canal in sufficient volume to establish a flow about 2.25 feet deep, and this depth of flow can be substantially maintained throughout the whole length of the sewer, by frequent admissions of canal water along its course.

"The sewer would intercept all of the sewers which now deliver into the canal throughout its whole course, *and it may be made to receive, by inexpensive iron siphons under the Hamburg Canal, the foul wastes of the industrial establishments on and near its south bank.* * * * The tumbling bay and tunnel under the canal, proposed by the first board of experts, was properly criticized by their successors. All such devices, leading to a disturbance of the flow, are objectionable and wasteful. The sewer should be carried under the canal by a gradual depression of the main line and on a course of easy reversed curves, with only such slight enlargement of its diameter as may be needed to compensate for the change of direction, reducing the velocity of flow as little as possible."

Concerning surface water, I said that a very large portion of the city area "is so nearly level that its surface water will reach the sewer slowly and very incompletely, and that much of it is so low that its surface water will not reach the sewer at all. * * * The discharge of the house sewage will always be far within the cleansing capacity of the cleansing current from the canal."

Concerning the Swan street location, I said:

"It is to be understood, of course, that whichever route is selected, the level at which the sewer is laid will be substantially the same, and that it will intercept as wide an area if

laid in Swan street as it would if laid at the bank of the Hamburg Canal. * * * The line along the bank of the Hamburg Canal will necessarily be expensive, both in matter of right of way and in the obvious difficulties in the construction of work at that point below the level of the canal. * * * The Swan street route, as indicated by frequent soundings, seems to escape quicksands entirely and to offer the most certain basis for estimate and the least obvious difficulty."

Of the district below Swan street, I said:

"It is, however, to be recommended that this district, and the manufacturing establishments south of the canal, be provided with a separate system of sewers to carry all of their flow to the intercepting sewer." It was also stated that the sewage of this district, between Swan street and the canal, might be intercepted by the present sewers if properly connected with the flushing inlets."

In my report, the purification of the Hamburg Canal, except by withholding filth from it, was not referred to.

My report was appended to a report of the Board of Sewer Commissioners of September 18, 1882, which adopted its general recommendations and which said:

"We have decided upon the Swan street line as the most practicable, and cheaper than the other routes. We do not favor the line through the Lower Terrace and the bank of the Hamburg Canal, for the reason that it is more circuitous and very much more expensive, and because it is doubtful if with the utmost care and skill it could be so constructed upon the bank of the canal and below the water line, as that the canal water would not leak into it. This route, too, would involve the payment of land damages to an unknown amount, and thus increase the cost of the sewer." * * * * * * *

"The bottom of the sewer in Swan street will be at the same level that it would be if placed in Seneca street, or on the bank of the canal, and, being below the water line of the

canal, insures a constant flow of water into the sewer from the canal, thus answering the double purpose of flushing the sewer and constantly changing the water in the canal."

Concerning the size of the sewer, the commissioners said:

"It is beyond controversy that a sewer of even less size would for a great many years and for a vastly increased population, receive and dispose of all the sewage proper, and it is a simple question of how much of the storm water shall be intercepted.

"The sewer of twelve feet in diameter, as heretofore proposed, did not take all the storm water, but was provided with overflows into the canals. The sewer we propose will not take as much storm water, but will take all of the water which falls in ordinary rains, and it is believed that the overflow into the canals would not occur many times a year. * * * * *

"In addition to this, as soon as the storm has ceased the current of water will flow from the canal into the sewer and the water thus drawn out will be replaced with fresh water from the slips.

"That portion of the city lying south of Swan street and north of the Hamburg Canal will continue to drain into the existing sewers, but our plans contemplate emptying the sewers in Seneca, Carroll, Folsom, Exchange and other streets into the flushing inlets in Washington, Chicago and Hamburg streets, and by proper methods thus diverting the sewage from the canal to the trunk sewer."

The Cost of the Sewer.

In the report of the first commission, no estimate of cost was given.

The report of the second commission was accompanied by a report of the city engineer, estimating the cost of the sewer as recommended at $1,381,105.

The city engineer recommended the substitution of Swan street for Seneca street and estimated the cost, if Swan street were adopted, at $1,406,782.

In the report of the commissioners of September 18, 1882, an estimate of the cost of the present sewer was made, based on the same units as were used in the above estimates. By this the present sewer should have cost $764,370.

The actual cost of the present sewer, including right of way, preliminary surveys, the plans for the Bird avenue connections and the Genesee street branch, and the construction of the Bird avenue junction chamber has been $1,025,623.88.

Changing the basis of the estimate so as to increase the city engineer's estimate of the cost of this sewer to what it really cost, we should have $1,871,575 as the cost of constructing the sewer recommended by the second commission, and $1,906,062 as the cost of constructing the same sewer on the Swan street line.

In every department, all branches of administration and construction have been carried on with absolute fidelity, and it cannot be supposed that good work under either of the above plans could have been secured at less proportionate cost. Indeed, an enlargement of the sewer from eight feet to eleven feet seven inches diameter in the tunnel under Swan street would doubtless have added enormously to the cost, if it indeed had not proved impracticable.

The Character of the Work.

No question has been raised, and none can be raised, as to the quality of the sewer. No better masonry was ever constructed under ground.

At one point, between Pearl street and Main street, there is a variation of the line of nearly six inches, due to the imperfect working of the iron shield in which the sewer was constructed for a short distance. At no other point is there a variation of one inch from the true line. Throughout nearly its whole course the bore of the sewer is as true as a gun barrel, and there is no possibility of its ever being disturbed, changed in form, or deteriorated in quality.

Description of the Sewer.

The main sewer begins at Hamburg street and ends at Niagara River below Albany street. Save for a slight increase in diameter, to compensate for curves in passing under the canal and harbor, its interior diameter is eight feet.

Its fall is uninterruptedly one foot in 4,656 feet, or about thirteen inches to the mile. (See figure 1.)

The ordinary level of the surface of Niagara River strikes the floor of the sewer at about Pearl street. In the absence of a current, water would stand in the sewer to a depth of one foot at Virginia street, two feet at Fort Porter, and three feet at Albany street.

The floor of the sewer descends nineteen feet from Albany street to its lowest point under the canal, thence it rises two and one-half feet to the bed of the river. At its outlet, the top of the sewer is 11.39 feet below the ordinary level of the river. It discharges at an angle to the direction of the current.

The effect of submerging the lower end of the sewer and a considerable length of its floor causes a slight theoretical retardation of the flow.

Practically, the "fall" of the sewer—and it is the only fall available whether the sewer were placed at a higher or a lower level—is the difference of elevation between the surface of the water in the Hamburg Canal and of that in the river at Albany street—ordinarily about four and a quarter (4.28) feet. This corresponds closely with the rate of inclination given to the sewer itself.

The Flushing Inlets.

There are three flushing inlets—one at Wilkeson slip, one at Chicago street and one at Hamburg street. The first two of these have their floor line on a level with the floor line of the trunk sewer.

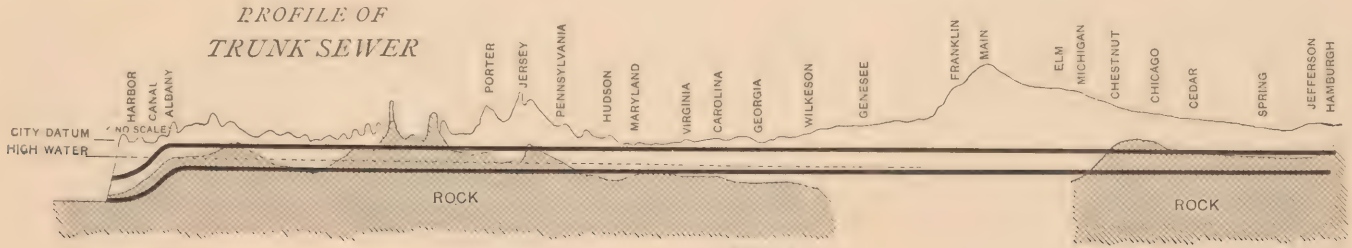

PROFILE OF
TRUNK SEWER
CITY DATUM
HIGH WATER
NO SCALE
HARBOR
CANAL
ALBANY
PORTER
JERSEY
PENNSYLVANIA
HUDSON
MARYLAND
VIRGINIA
CAROLINA
GEORGIA
WILKESON
GENESEE
FRANKLIN
MAIN
ELM
MICHIGAN
CHESTNUT
CHICAGO
CEDAR
SPRING
JEFFERSON
HAMBURGH
ROCK
ROCK

Fig. 1.

Each of these flushing inlets is provided with automatic gates, which allow water to pass freely from the canal into the sewer, but will not allow it to pass from the sewer into the canal. When, by rain, the water in the sewer is raised above the level of the canal these gates, if kept in proper condition, should close themselves.

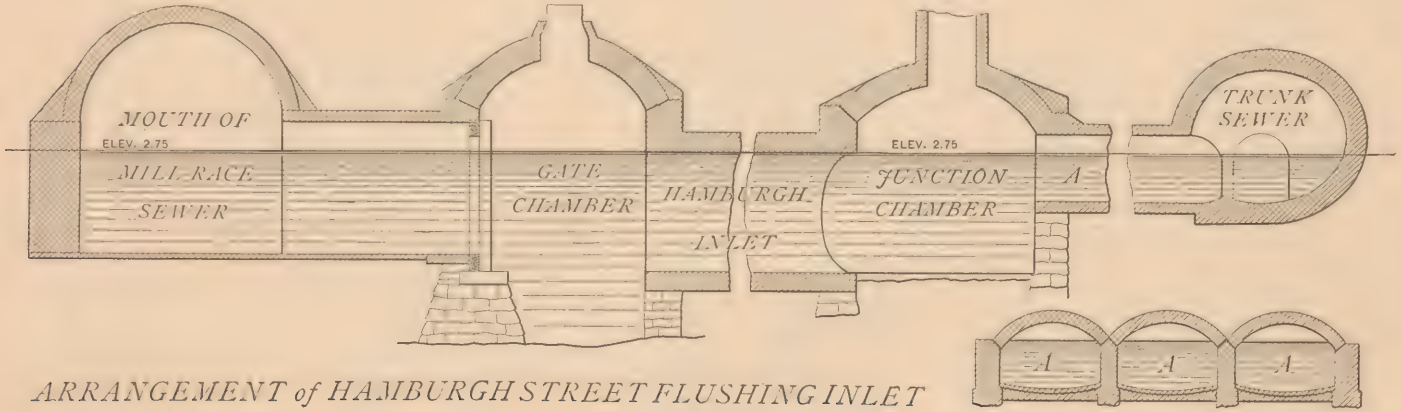
The Hamburg street inlet has its floor four and one-quarter (4.25) feet below the floor line of the trunk sewer. The relation of this inlet with the canal and with the sewer is shown in the accompanying sketch. (Figure 2.)

It has been suggested that so much of this inlet as lies below the level of the trunk sewer will become filled with deposit, owing to the stagnation of the water below the "dead water" line. This is an error. Water flows in mass, not in layers. A body of water having a point of discharge above the level of its bottom moves in mass toward that point, a little, but not much, more slowly at the bottom than at the top. Eel-grass growing at the bottom of a deep mill-pond, from which the water is escaping at comparatively slight depth over the top of the dam is, by the bottom current, swept toward the dam. Where the bottom is bare, if the flow through the pond is considerable, it is generally sandy, clay and lighter silt being removed by the current. If we stir the ground at the bottom of such a pond, the particles that we loosen flow immediately forward toward the dam.

The cause of these effects is operative in the Hamburg street inlet. The flow at the bottom is less than at the top, but not materially less. There is no deposit of moment in this inlet after eleven months' work.

The reason for depressing this conduit is simple to understand. It was desired to carry the level of the Hamburg Canal water to the side of the trunk sewer, with the least possible loss of head from friction, without making the conduit inordinately large.

Had it been laid at the level of the sewer it would have run less than half full, with nearly as much frictional resistance,



ARRANGEMENT of HAMBURGH STREET FLUSHING INLET

Fig. 2

From Junction Chamber to Trunk Sewer

at the same velocity, as though running full. By lowering the conduit and filling it full, the capacity of the channel was increased, the relative friction was reduced and the best effect was secured.

Had the inlet sewer been laid so high that its bottom would be on the same level with the bottom of the trunk sewer, the cross section of its current would have been only 16.11 square feet. Being entirely submerged, as it is, the cross section of its current is 41.28 square feet.

The theoretical resistance by friction being 1.59 in the case of the high sewer, it would be only 1.81 in the case of the low sewer, though carrying two and one-half times as much flow.

The Interception of the City Sewers.

The connection of the trunk sewer with the city sewers is shown in Figure 3, representing the Porter avenue interception. The dry-weather flow of the sewer is delivered at an angle of forty-five degrees with the course of the trunk sewer through a cast-iron pipe two feet in diameter. The bottom of this pipe is one foot above the bottom of the sewer and its top is one foot below the middle of the sewer.

For dry weather and light rains, this would suffice. In order to secure the introduction of as much as possible of the discharge of the city sewers during heavy storms, it was arranged that its flow should be somewhat stilled in a well over the mouth of the inlet pipe, to allow the escape of the large volume of air sometimes involved in the rapid current of steep sewers during storms. This is so done as to bring the full head of the intercepted sewer to bear on the inlet.

So much of the flow as cannot gain access to the trunk sewer through the lower inlet, passes on over the vertical well and runs into it through a three-foot opening in its crown. Should the sewer be so full that the entire flow of the intercepted sewer cannot gain admission, the surplus passes on to

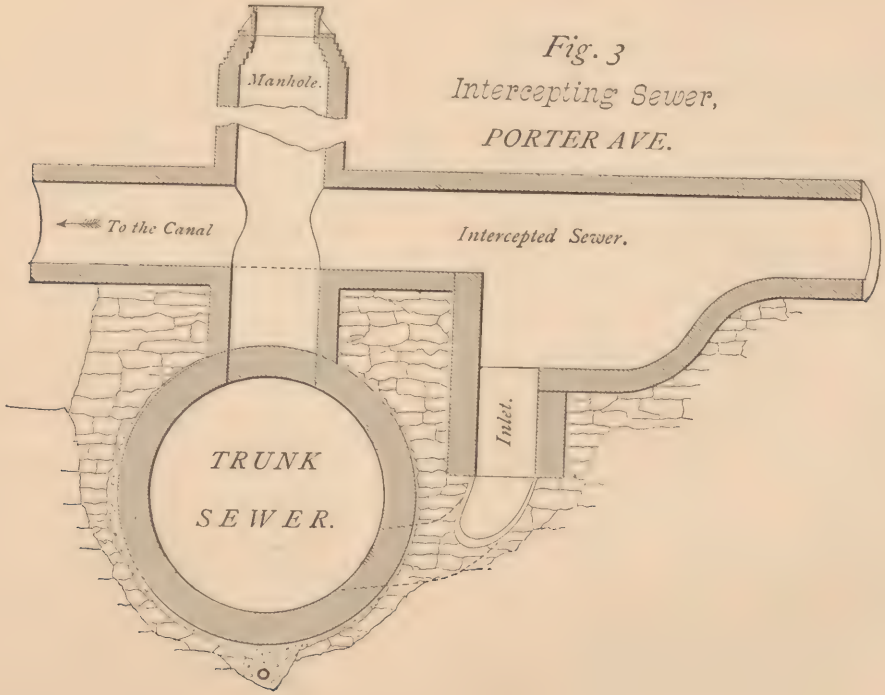


Fig. 3

Intercepting Sewer,

PORTER AVE.

the canal. (At such times, the greater head of water in the trunk sewer than in the canal will cause the automatic gates of the flushing inlets to close and prevent escape by these channels.)

The Mill-Race Connection.

There is a four-foot sewer connecting the bottom of the Mill-race sewer at Hydraulic street and Seneca street with the head of the trunk sewer at Hamburg street. This is capable of carrying all of the ordinary dry-weather flow of the Mill-race sewer.

During storms, the volume flowing through it is more than can be intercepted at this point and the surplus flows on through the old channel toward the head of the Hamburg Canal.

The Working of the Sewer.

The volume of dry-weather flow passing through the sewer is materially affected by the height of the canal, which changes according to the direction and force of the wind.

On Friday, October 8, 1886, the weather had been fair for some time; the wind had been light and was then very light. At that time, in company with Mr. Guthrie, of the city engineer's office, I made an examination of the inlets and of the sewer in Swan street. The level of the lake was 2.29 below city datum—somewhat lower than the level assumed in constructing the sewer. Water was flowing toward the sewer at the Chicago street inlet and at the Hamburg street inlet. The current was stronger at Chicago street than at Hamburg street, but it was strong there. The depth of the stream in the Chicago street inlet was 3.5 feet. The Chicago street inlet was free from deposit, as tested by sounding with a light rod at manholes.

In the Hamburg street inlet there was a very light deposit eighteen inches deep. This was so light that a steel rod five

feet long and one-half inch in diameter, lowered by a string, sank slowly through the deposit and struck the bottom of the sewer. At the point sounded in Swan street, there was no deposit whatever save about one inch of grit that had fallen through the openings of the manhole.

The wind remained very light during the whole of the next twenty-four hours. On the afternoon of Saturday (the 9th) Mr. Record tested the flow and the volume of water in the sewer at the water works. He reports as follows:

Depth of water, 3.22 feet.

Mean velocity, 142 feet per minute (2.37 feet per second).

Area of cross section of current, 23.63 square feet.

Discharge per minute, 3,555 cubic feet (26,591 gallons).

Discharge per twenty-four hours, 36,233,280 gallons.

A comparison of these figures, with those given in the earlier parts of this paper, will show that the sewer is carrying a deeper stream, flowing at a greater velocity, than there proposed.

During periods of high water, under the influence of strong westerly winds, the volume and velocity are largely increased.

The interception of the *dry-weather* flow of every sewer from the Mill-race to Albany street (inclusive) is complete, save that the Washington street sewer, a short one, still flows into the Hamburg Canal and the Erie street sewer, which has a very short length above the line of the trunk sewer, flows into Erie Canal. The latter is of no moment. The former will be intercepted with the other sewers between Swan street and the Hamburg Canal.

It will thus be seen that the trunk sewer is doing all that it was originally proposed to do. Two sources of complaint, however, exist. The first relates to foul odors escaping through the perforated manhole covers along Swan street. It was a mistake to use perforated covers here. Solid covers will be substituted for them. The odors complained of are due mainly to the foul character of the flow of the Mill-race

sewer, which drains the stock-yards, slaughter houses, and other foul establishments in East Buffalo. It is in no sense what is generally understood as "sewer gas," and, though disagreeable, it is not probably especially dangerous. There is no objection to confining it in the sewer. There is no possible chance for the atmosphere of the trunk sewer in Swan street to find its way into houses along its line, nor along the line of sewers intercepted by it. The houses in Swan street have their own independent sewers, and these, as well as the Spring street and Michigan street sewers, are protected against the return of air from the trunk sewer. This relates to the sewer from Hamburg street to the Terrace. Below there, no complaint is made, and, as the atmosphere of the sewer is in free communication with the intercepted sewers leading to the canal, there is no reason why solid covers may not be used over the manholes here, if desired.

The other source of complaint is

The Condition of the Hamburg Canal.

The water of this canal is underlaid by foul recent deposits of organic refuse in an active state of decomposition. Its surface, for its entire length, is spotted with bubbles of the escaping gas. The accumulation of gases produced within the mass at the bottom of the canal frequently throws up great volumes of putrid filth. This was the condition of the canal before the work was undertaken, and, although greatly modified, it is not yet entirely removed.

The capacity of the trunk sewer to purify the canal was amply demonstrated when the gates were first opened last year. On the fifteenth of November the canal was probably as foul as it ever was. The first gate, one of the two at the Hamburg street inlet, was opened at 3 P. M. on that day; the other was opened early on the 16th. The Chicago street gates were both open on the 17th. On the evening of the

15th Mr. Gorham, one of the sewer commissioners, said to a reporter of the *Courier*: "The effect upon the canal was at once perceptible. The current from the canal into the inlet is very rapid, and in the space of an hour the upper end of the canal was clear of large portions of the scum lying upon its surface."

On the 17th the canal was full of lake water—that is, lake water, free from the floating matters and from the discolorations so perceptible on the 15th, extended all the way to Hamburg street.

This condition was maintained throughout the 18th. Naturally, all interested in the sewer were much elated, and assumed that the very difficult problem had been solved, for good and all. I am conscious of having, under the influence of this feeling, used expressions as to the purification of the canal which were afterwards found not to be warranted. That night, the wind blew strongly from the northeast, lowering the water of the lake, and a heavy rain fell. The Mill-race sewer, which had been a quiet dry-weather rivulet for some time before, now became a torrent, bringing with it a mass of stock-yard manure, hog-car slush, slaughter-house offal, tannery waste and all manner of foul rubbish, which during dry weather had accumulated over a large part of its stinking water-shed. This torrent, rushing past the mouth of the Hamburg inlet, swept its filthy burden into the canal, and, in addition, stirred up and carried forward the considerable deposits already formed there.

Realizing the gravity of this condition, I addressed the Board of Sewer Commissioners on the twenty-third of November, advising them to place gates at the head of the canal which would close when the Mill-race sewer should be swollen by storm water, forcing a large part of its discharge to find an outlet through the Hamburg inlet and the trunk sewer, the surplus overflowing over the tops of the gates into the canal,

with its direct force broken and in such a manner as not materially to stir up the canal deposits. In support of this recommendation I said:

"I have been considering the conditions existing at the upper end of the Hamburg Canal on Thursday last, and have arrived at the conclusion, with which I think all will agree, that when there is a heavy or long continued rain concurrently with a low lake—and rain is most likely to come with an easterly wind which makes a low lake—the Mill-race sewer will discharge more water than the four-foot sewer and the Hamburg inlet can receive at a low stage of water. Whenever these conditions concur, the state of affairs that existed last Thursday is likely to return. That is to say, so strong a stream will be thrown into the canal as to stir up its deposits and reverse its current so as to foul it for its whole length. This would not be very serious if this were all, because the deposits will probably disappear before very long.

"But the Mill-race sewer itself is a very foul sewer. It is foul at all times and especially so during rains that are heavy enough to wash the filth of the cattle yards into the stream. Therefore, even after the canal shall have become clean by natural processes, every rain will bring into it enough filth from this source to go far toward fouling it again. The chances of difficulty on this score are sufficient to make it seem necessary to adopt some means of relief."

These gates have not yet been constructed, but a continued observation of the effect of floods in the Mill-race sewer has only emphasized the need for them.

Figure 4 shows the plan proposed. The gate shown will swing open to admit canal water to the sewer in dry weather, as now. During storms it will close and force the flow of the Mill-race sewer, which now pours its filth into the canals, to find its outlet directly through the trunk sewer.

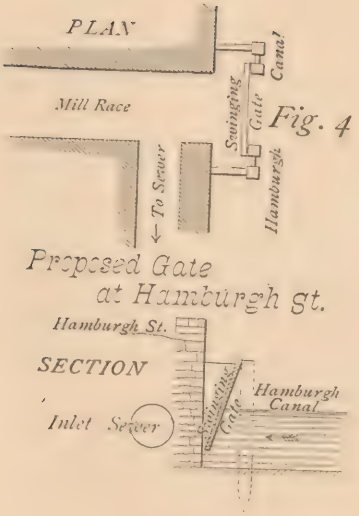

PLAN
Mill Race
To Sewer
Swinging Gate
Hamburgh Canal
Proposed Gate at Hamburgh St.
Hamburgh St.
SECTION
Inlet Sewer
Swinging Gate
Hamburgh Canal

Fig. 4

The amount of foul sewage flowing into the canal from the south is very large, and the best condition of the canal water can never be attained until the original suggestion of the commissioners, to carry this sewage across the canal into the flushing inlets of the trunk sewer, shall have been carried out.

However, in spite of this south-side sewage, and of the frequent very serious additions to the deposits due to storm floods in the Mill-race sewer, the condition of the canal is very much better than it was before the flushing gates were opened. For example :

1. The canal was frozen over last winter for the first time in many years.

2. Canal water is used for the condensers of the Grape Sugar works near Chicago street. Until the flushing gates were opened, it was necessary to stop the works several times during the day in order to cleanse the condensers of the accumulated scum. Since the flushing gates were opened, now nearly eleven months, they have run continuously without the need for cleansing.

The Means of Relief.

I believe that three things are necessary to the complete purification of the Hamburg Canal, viz.:

1. The interception (for which plans have been prepared) of the sewers between Swan street and the Hamburg Canal.

2. The delivery into the trunk sewer of all the foul sewage —domestic or manufacturing—now entering the canal directly or indirectly from the south.

3. The construction of the proposed gates at the head of the Hamburg Canal, to divert the storm flow of the Mill-race sewer to the Hamburg inlet.

These three things being done—and the third is now in contemplation—the processes which have so much improved the condition of the Hamburg Canal will soon secure its entire purification.

It will not be necessary to dredge out the present foul deposits in the canal; they will soon be destroyed by decomposition. All that is needed is to stop adding to them, as at present.

NEWPORT, R I., October 13, 1886.

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NEWPORT, R. I.

SPECIAL ATTENTION GIVEN TO

SEWERAGE AND HOUSE DRAINAGE.